

2021 IEEE India Geoscience and Remote Sensing Symposium (InGARSS)

Proceedings

6 – 10 December 2020
Virtual Symposium

IEEE Catalog Number: CFP21U63-ART
ISBN: 978-1-6654-4249-7

2021 IEEE India Geoscience and Remote Sensing Symposium (InGARSS)

Proceedings

6 – 10 December 2020
Virtual Symposium

Sponsored by

The Institute of Electrical and Electronics Engineers
Geoscience and Remote Sensing Society

IEEE Catalog Number: CFP21U63-ART
ISBN: 978-1-6654-4249-7



IEEE



TABLE OF CONTENTS

TU4-H1: LAND, FOREST & ENVIRONMENT-1

TU4-H1.2: TIME SERIES ALOS-2/PALSAR-2 SAR DATA AND MULTI-TEMPORAL ICESAT-2 LIDAR DATA FOR FOREST ABOVE-GROUND BIOMASS RETRIEVAL 1

Mohamed Musthafa, Indian Institute of Technology, Bombay, India; Gulab Singh, Bala Raju Nela, Indian Institute of Technology Bombay, India

TU4-H1.3: IDENTIFICATION OF BARK BEETLE INFESTATION IN PART OF BOHEMIAN FOREST USING SENTINEL-1 TIME SERIES INSAR 5

Mohammed Sultan Alshayef, Charles University, Czechia; Mohamed Musthafa, Indian Institute of Technology Bombay, India

TU4-H1.4: TIME-SERIES ANALYSIS OF C- BAND AND L-BAND SAR BACKSCATTER IN DETECTING FOREST DISTURBANCE AND REGROWTH DYNAMICS 10

Mohamed Musthafa S, Gulab Singh, Bala Raju Nela, Indian Institute of Technology Bombay, India

TU4-H1.5: PLANNING FOR MITIGATING FLASH FLOOD EVENTS: A CASE OF ALMORA DISTRICT IN UTTARAKHAND 14

Rajat Dabral, Sardar Vallabhbhai National Institute of Technology, Surat, India; Anugrah Anilkumar Nagaich, Maulana Azad National Institute of Technology, Bhopal, India

TU4-H2: OCEAN & OCEANSAT-1

TU4-H2.3: OCM-3 AND SSTM-1 PAYLOADS ON OCEANSAT-3 (EOS-06) MISSION 23

Somya Sarkar, Vishnu Patel, Indian Space Research Organisation, India

TU4-H2.4: OCEANSAT-3 (EOS-6) PRODUCTS AND APPLICATIONS 27

Pradeep Thapliyal, Indian Space Research Organisation (ISRO), India

TU4-H2.5: NCMRWF SEAMLESS ASSIMILLATION PREDICTION SYSTEM: UTILISATION OF OCEANSAT-3 30

Ashis K. Mitra, National Centre for Medium Range Weather Forecasting (MoES), India; John P. George, S. Indira Rani, V S Prasad, NCMRWF, MoES, GoI, India, India

TU4-H3: ADVANCED REMOTE SENSING-1

TU4-H3.2: LOW-COMPLEXITY RECONFIGURABLE COMPUTING BASED ONLINE ONE-CLASS CLASSIFICATION USING HIGH-RESOLUTION HYPERSPECTRAL IMAGERY 33

Dubacharla Gyaneshwar, Rama Rao Nidamanuri, Indian Institute of Space Science and Technology, India

TU4-H3.3: SIMULATION AND ANALYSIS OF STAGGERED PRI SEQUENCE FOR NISAR..... 37

Samneet Thakur, Krishna Murari Agrawal, V Manavalan Ramanujam, Space Applications Centre, India

TU4-H3.4: 3DYOLO: REAL-TIME 3D OBJECT DETECTION IN 3D POINT CLOUDS FOR AUTONOMOUS DRIVING 41

Priya M V, Dhanya S Pankaj, COLLEGE OF ENGINEERING TRIVANDRUM, India

TU4-H3.5: ESTIMATION OF GROUND DISPLACEMENT IN SAN FRANCISCO BAY AREA USING A SPATIO-TEMPORAL UNWRAPPING NETWORK BASED PSINSAR ALGORITHM 45

Kousik Biswas, Debashish Chakravarty, Pabitra Mitra, Indian Institute of Technology Kharagpur, India; Rishabh Panda, Kalinga Institute of Industrial Technology, India; Pavan Kumar M., MVJ College of Engineering, India; Arundhati Misra, Space Applications Centre, ISRO, India; Dibyendu Ghosh, Intel Corporation, India; Prosenjit Banerjee, One Plus, India

TU4-H4: AGRICULTURE, HYDROLOGY & CRYOSPHERE-1

TU4-H4.2: TRISHNA: AN INDO-FRENCH SPACE MISSION TO STUDY THE THERMOGRAPHY OF THE EARTH AT FINE SPATIO-TEMPORAL RESOLUTION 49

Jean-Louis Roujean, Gilles Boulet, Olivier Hagolle, CESBIO, France; Bimal Bhattacharya, M.R. Pandya, S.K. Singh, M.V. Shukla, M. Mishra, D. Adlakha, M. Sarkar, M. Sekhar, ISRO, India; Philippe Gamet, Emilie Delogu, Philippe Maisongrande, CNES, France; Albert Olioso, Mark Irvine, INRAE, France; Xavier Briottet, ONERA, France; Auline Rodler, CEREMA, France; Emmanuelle Autret, IFREMER, France; Isabelle Dadou, Alexei Kouraev, LEGOS, France; Ghislain Picard, IGE, France; Cécile Ferrari, IPGP, France; Thomas Vidal, ACRI, France; Kaniska Mallick, LIST, Luxembourg

TU4-H4.3: FLOOD FREQUENCY ANALYSIS USING ERA5-LAND BASED PRECIPITATION FOR KOSI-MAHASETU STATION IN NORTH BIHAR, INDIA 53

Gaurav Tripathi, Central University of Jharkhand, Brambe, India, India; Arvind Chandra Pandey, Bikash Ranjan Parida, Central University of Jharkhand, India

TU4-H4.4: CNN-BASED FUSION AND CLASSIFICATION OF MULTI-TEMPORAL SENTINEL-1 & -2 SATELLITE DATA 57

Achala Shakya, Mantosh Biswas, Mahesh Pal, National Institute of Technology Kurukshetra, Haryana, India

TU4-H4.5: COMPARISON OF SPECKLE NOISE FILTERS ON CROP CLASSIFICATION BASED ON SENTINEL-1 SAR TIME-SERIES 61

Arturo Velasco Alvarez, Doctoral Student, Canada; Bernhard Rabus, Mirza Faisal Beg, Professor, Canada

TU5-H1: LAND, FOREST & ENVIRONMENT-2

TU5-H1.1: A MODIFIED NEURAL NETWORK FOR LAND USE LAND COVER MAPPING OF LANDSAT-8 OLI DATA 65

Vikash Kumar Mishra, Indian Institute of Information Technology ,Allahabad, India; Dinesh Swarnkar, Indian Institute of Information technology Allahabad, India; Triloki Pant, Indian Institute of Information Technology Allahabad, India

TU5-H1.2: GENERATION OF DETAILED CLASSIFICATION MAPS USING HIGH-RESOLUTION SATELLITE IMAGES AT COUNTRY-WIDE SCALE70

Prajowal Manandhar, UAE University, United Arab Emirates; Ahmad Jalil, Sultan Zehi, Sanad Fareaa, NSSTC, United Arab Emirates; Prashanth Marpu, Group 42, United Arab Emirates

TU5-H1.4: MAPPING GLOBALLY USING MULTITEMPORAL SENTINEL-1 SAR: A SEMIAUTOMATIC APPROACH74

David Marzi, Paolo Gamba, University of Pavia, Italy; Shantanu Todmal, Indian Institute of Information Technology, India

TU5-H1.5: A PRELIMINARY STUDY AND ANALYSIS ON EXTRACTION OF URBAN AREA DENSITY USING POLSAR IMAGES78

Amit Kumar, Rajib Panigrahi, Indian Institute of Technology Roorkee, India

TU5-H1.6: GABOR AND PCA FEATURE-BASED UNSUPERVISED CHANGE DETECTION IN SAR IMAGES 82

V.V.N Sujit, National Institute of Technology, Rourkela, India; Umesh C Pati, National Institute of Technology, India

TU5-H2: OCEAN & OCEANSAT-2

TU5-H2.1: OCEANSAT-3 APPLICATIONS FOR CYCLONE STUDIES 86

Mrutyunjay Mohapatra, Ashim Mitra, India Meteorological Department, Lodi Road, New Delhi, India

TU5-H2.2: OCEANSAT3 APPLICATIONS FOR OCEAN STATE FORECAST AND POTENTIAL FISHING ZONES SERVICES	90
<i>Dr. Balakrishnan Nair, Nimit Kumar, Aneesh Lotlike Lotlike, Anuradha Modi, Sudheer Joseph, Indian National center for Ocean Information Services, India</i>	
TU5-H2.3: COMPARATIVE ANALYSIS OF CHLOROPHYLL-A MEASUREMENTS OF OCEANSAT-2 OCM AND SUOMI NPP- VIIRS OVER ARABIAN SEA	94
<i>Rimjhim Bhatnagar, Mini Raman, Marine Ecosystem Division, Space Applications Centre, ISRO, Ahmedabad, India</i>	
TU5-H2.4: ESTIMATION OF SHALLOW WATER BATHYMETRY USING LINEAR WAVE DISPERSION THEORY ON A SINGLE RESOURCESAT-2 LISS-IV IMAGE NEAR INDIAN EAST COAST	98
<i>Mohammed Suhail, Runjhun Chandra, Muralikrishnan S, Nagamani PV, National Remote Sensing Centre (NRSC), India</i>	
TU5-H2.5: INVESTIGATION OF THE RELATIONSHIP OF CYGNSS OBSERVABLES WITH OCEAN WAVE PARAMETERS	102
<i>Megha Maheshwari, Akhilesh Kumar, Nirmala Srini, U R Rao Satellite Centre, India; Arun Chakraborty, IIT kharagpur, India</i>	
TU5-H2.6: COASTAL UPWELLING DURING NORMAL AND EL NINO YEARS: CASE STUDY OF PERU AND OMAN UPWELLING	107
<i>Debojyoti Ganguly, Mini Raman, Space Applications Centre, India</i>	
TU5-H2.7: RELATING BIOLOGICAL PRODUCTIVITY TO TEMPERATURE FRONTS IN THE NORTHERN INDIAN OCEAN	111
<i>Amala Mahadevan, Jing He, Gualtiero Jaeger, Woods Hole Oceanographic Institution, United States</i>	
TU5-H3: ADVANCED REMOTE SENSING-2	
TU5-H3.1: MODEL-BASED NINE-COMPONENT SCATTERING MATRIX POWER DECOMPOSITION OF POLSAR DATA	114
<i>Rashmi Malik, Onkar Dikshit, IIT Kanpur, India; Gulab Singh, IIT Bombay, India; Yoshio Yamaguchi, Niigata University, Japan</i>	
TU5-H3.2: RFI DETECTION AND SUPPRESSION IN L & S BAND AIRBORNE SAR	118
<i>Parikshit Parasher, Krishna M Agrawal, V M Ramanujam, Space Applications Centre, India</i>	
TU5-H3.4: ANGKOR WAT DEFORMATION MONITORING FROM 2017 TO 2021	122
<i>Vignesh Kandasamy, Thazhal Geospatial Analytics, India; Shashi Kumar, Indian Institute of Remote Sensing, India</i>	
TU5-H3.6: EXTRACTION OF WATER BODIES FROM VISIBLE COLOR SATELLITE IMAGES USING PCA FEATURE MAP	129
<i>Deepa Sharma, IIIT Bhopal, India; Trapti Sharma, VIT Bhopal, India; Jyoti Singhai, Maulana Azad National Institute of Technology, India</i>	
TU5-H4: AGRICULTURE, HYDROLOGY & CRYOSPHERE-2	
TU5-H4.1: SPATIAL TRENDS IN RAINFALL SEASONALITY INDEX OVER MARATHWADA REGION OF MAHARASHTRA STATE, INDIA	133
<i>Himanshu Bana, Prof. R. D. Garg, Indian Institute of Technology Roorkee, India</i>	
TU5-H4.4: EXTRACTION OF WATER BODIES IN GODAWARI BASIN FROM SATELLITE IMAGES	141
<i>Suhas Kale, Bharti Gawli, Dr. B.A.M.University, Aurangabad (MS), India; Shafiyoddin Sayyad, Milliia College, Beed, India, India</i>	

TU5-H4.5: CNN BASED WATER STRESS DETECTION IN CHICKPEA USING UAV BASED HYPER SPECTRAL IMAGING	145
<i>Adduru U G Sankararao, Gattu Priyanka, Rajalakshmi P., Indian Institute of Technology Hyderabad, India; Sunitha Choudhary, International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, India</i>	
TU5-H4.6: RAINFALL MAPPING USING MACHINE LEARNING ALGORITHM	149
<i>Nyenshu Seb Rengma, Manohar Yadav, Motilal Nehru National Institute of Technology Allahabad, India</i>	
WE1-H4: STUDENT SESSION-1	
WE1-H4.1: INTER AND INTRA-ANNUAL SPATIO-TEMPORAL VARIABILITY OF HABITAT SUITABILITY FOR ASIAN ELEPHANTS IN INDIA: A RANDOM FOREST MODEL-BASED ANALYSIS	467
<i>Anjali P, Deepak N. Subramani, Indian Institute of Science, India</i>	
WE1-H4.2: DEEP LEARNING-BASED EMULATOR FOR 6S ATMOSPHERIC CORRECTION MODEL	471
<i>Maitrik Shah, Student Member, IEEE, India; Mehul Raval, Senior Member, IEEE, India; Srikrishnan Divakaran, Ahmedabad University, India, India</i>	
WE1-H4.3: PREDICTING UNKNOWN CLASSES ON HYPER SPECTRAL IMAGE DATA USING DEEP LEARNING TECHNIQUES	475
<i>Surabhi Khare, Liverpool John Moores University, Liverpool, UK; upGrad Education Pvt. Ltd., Worli, Mumbai - 400018, India; Sanchit Aggarwal, upGrad Education Pvt. Ltd., Worli, Mumbai - 400018, India</i>	
WE1-H4.4: SEMANTIC SEGMENTATION OF URBAN AREAS IN POLARIMETRIC SAR IMAGING USING DEEP NEURAL NETWORKS AND DECISION TREES	479
<i>Tripti Kumari, Indian Institute of Information Technology, Ranchi, India, India; Farhan Hai Khan, Rintu Kumar Gayen, Institute of Engineering & Management, Kolkata, India, India; Tamesh Halder, Debashish Chakravarty, Indian Institute of Technology, Kharagpur, India, India; Arundhati Mishra Ray, Indian Space Research Organization, Ahmedabad, India, India</i>	
WE1-H4.5: A MACHINE LEARNING FRAMEWORK FOR DATA FILTERING: A CASE STUDY ON CHANDRAYAAN-1 SIR-2 DATA	483
<i>Karan Bhuva, Parth Patadiya, Hetvi Julasana, Suchit Purohit, Gujarat University, India; Megha Bhatt, Physical Research Laboratory, India; Deepak Dhingra, Indian Institutes of Technology, Kanpur, India; Urs Mall, Max Planck Institute for Solar System Research, Germany</i>	
WE1-H4.6: A DEEP LEARNING FRAMEWORK FOR FUSION OF SAR AND OPTICAL SATELLITE IMAGERY	488
<i>Neeharika Gupta, Thota Sivasankar, NIIT University, India; Hari Shanker Srivastava, Indian Institute of Remote Sensing, ISRO, India; Parul Patel, Space Applications Centre, ISRO, India</i>	
WE1-H4.7: INTEGRATION OF SAR (SENTINEL -1A) AND OPTICAL (SENTINEL -2A) DATA FOR LITHOLOGY DISCRIMINATION IN ARID TRACTS OF THE THAR DESERT (NAGAU, RAJASTHAN)	492
<i>Raja Biswas, Virendra Singh Rathore, Akhouri Pramod Krishna, Birla Institute of Technology, India; Gulab Singh, Indian Institute of Technology, India; Anup Kumar Das, Space Applications Centre, India</i>	
WE1-H4.8: ITERATIVE EMPIRICAL ORTHOGONAL FUNCTION IN GAP FILLING OF GPS AND INSAR DATA	496
<i>Neha Neha, Birla Institute of Technology and Science, Pilani, Pilani Campus, India; Sharat Mehrotra, Himanshu Verma, Sumanta Pasari, Birla Institute of Technology and Science, Pilani, Pilani Campus, Jhunjhunu – 333031, Rajasthan, India</i>	
WE1-H4.9: AN IMPROVED IHS IMAGE FUSION ALGORITHM USING MEDOID INTENSITY MATCH AND BILATERAL FILTER	500
<i>Manan Manoj Tiwari, Bennett University, India; Indranil Misra, S. Manthira Moorthi, Debajyoti Dhar, Space Applications Centre, ISRO, India</i>	

WE1-H4.10: INTEGRATION OF DESIS WITH MULTISPECTRAL DATA FOR GEOLOGICAL ANALYSIS OF CUPRITE HILLS FROM NEVADA	504
<i>Prateek Tripathi, Rahul Dev Garg, Indian Institute of Technology, Roorkee, India</i>	
WE1-H4.11: HYPERSPECTRAL DATA ASSIMILATION AND ROAD MATERIAL EXTRACTION	508
<i>Ankit Chandelia, Parul Patel, Dhwanilnath Gharekhan, School of Engineering, Institute of Technology, Nirma University, India</i>	
WE1-H4.12: SENSITIVITY ANALYSIS OF GNSS-IR BASED MULTIPATH PHASE FOR SOIL MOISTURE OVER WINTER WHEAT CROP USING NAVIGATION WITH INDIAN CONSTELLATION (NAVIC)	512
<i>Sushant Shekhar, Rishi Prakash, Anurag Vidyarthi, Graphic Era Deemed to be University, India; Dharmendra Kumar Pandey, Deepak Putrevu, Arundhati Misra, ISRO, India</i>	
WE1-H4.13: OBSERVING SEASONAL VELOCITY CHANGES OF SVALBARD GLACIERS USING DIFFERENTIAL SAR INTERFEROMETRY (DINSAR) TECHNIQUE	516
<i>Bala Nela, Gulab Singh, Mohamed Musthafa, IIT Bombay, India; Rajat Rajat, Birla Institute of Technology Mesra, India; Andrey Glazovsky, Institute of Geography, Russian Academy of Sciences, Russia</i>	
WE1-H4.14: DUAL POLARIMETRIC SAR SIGNATURE FOR HUMAN-MADE TARGET CHARACTERIZATION	520
<i>Abhinav Verma, Subhadip Dey, Narayanarao Bhogapurapu, Avik Bhattacharya, Indian Institute of Technology Bombay, India; Carlos Lopez-Martinez, Universitat Politècnica de Catalunya (UPC), India</i>	
WE1-H4.15: STUDY ON PROACTIVE AND REACTIVE ROUTING APPROACHES FOR FLYING AD-HOC NETWORKS	524
<i>Sagnik Banerjee, Snehasish Basu, Arindam Basak, Kalinga Institute of Industrial Technology, BHUBANESWAR, India; Tamesh Halder, Debashish Chakravarty, Indian Institute of Technology, Kharagpur, India; Amit Kumar Das, Institute of Engineering & Management, Kolkata, India; Sajal Sarkar, Power Grid Corporation of India Ltd., India; Arundhati Mishra Ray, Indian Space Research Organization, India</i>	
 WE2-H1: AGRICULTURE, HYDROLOGY & CRYOSPHERE-3	
WE2-H1.2: CLASSIFICATION AND IDENTIFICATION OF CROPS USING DEEP LEARNING WITH UAV DATA	153
<i>Abhishek Narvaria, International Institute of Information Technology (IIIT) Bangalore, India; Uttam Kumar, Kanumuru Shree Jhanwwee, Anindita Dasgupta, IIIT Bangalore, India; Gurdeep Jyoti Kaur, Birla Institute of Technology (BIT) Mesra, India</i>	
WE2-H1.3: A GEO-SPATIAL APPLICATION FOR BROWN PLANT HOPPER PEST RISK PREDICTION OVER RICE GROWING AREAS OF INDIA	157
<i>Parmita Ghosh, Sonal Bakiwala, Sunil Samson, Anuradha Swatantran, Corteva Agriscience, India</i>	
WE2-H1.4: ANALYSIS OF SVALBARD GLACIER MOVEMENT AT DIFFERENT PENETRATION DEPTHS USING C AND L-BAND DIFFERENTIAL INTERFEROMETRIC SYNTHETIC APERTURE RADAR (DINSAR) TECHNIQUE	161
<i>Bala Nela, Gulab Singh, Mohamed Musthafa, Indian Institute of Technology Bombay, India; Rajat Rajat, Birla Institute of Technology Mesra, India; Andrey Glazovsky, Institute of Geography, Russian Academy of Sciences, India</i>	
WE2-H1.5: ESTIMATION OF ICE THICKNESS DISTRIBUTION OVER RAIKOT GLACIER IN NANGA PARBAT REGION: A GEOSPATIAL APPROACH	165
<i>Afaan Gulzar Mantoo, Fayma Mushtaq, Majid Farooq, Department of Ecology, Environment and Remote Sensing, Government of Jammu and Kashmir, India, India; Mili Ghosh Nee Lala, Department of Remote Sensing, Birla Institute of Technology Mesra, Ranchi, India, India</i>	

WE2-H2: GEOSCIENCE-1

WE2-H2.2: MULTIFREQUENCY AND MULTIPOLARIZATION HIGH-RESOLUTION SAR 169 DATASETS FOR DEMARCATION OF STRUCTURAL PATTERN OF BASE METAL BEARING CARBONATE ROCKS OF ZAWAR REGION

Ronak Jain, Banasthali Vidyapith, India; Harsh Bhu, Ritesh Purohit, Mohanlal Sukhadia University, Udaipur, India

WE2-H2.3: DAMAGE ASSESSMENT POST SEVERE CYCLONIC STORM “YAAS” USING 173 SYNTHETIC APERTURE RADAR

Hrishikesh Kumar, D Ram Rajak, Space Applications Centre-ISRO, India; Tajdarul Hassan Syed, Indian Institute of Technology, Kanpur, India

WE2-H2.4: SOIL EROSION MODELING AND PRONE AREA PRIORITIZATION USING 177 GIS-BASED RUSLE MODEL, CASE OF THE BOUHANIFIA BASIN IN WESTERN ALGERIA

Youcef Fekir, Mohamed Amine Hamadouche, University Mustapha Stambouli of Mascara, Algeria; Khalladi Mederbal, University of Ibn Khaldoun Tiaret, Algeria; Mohamed Larid, University of Abdelhamid Ibn Badis Mostaganem, Algeria; Djamel Anteur, University of Moulay Taher Saida, Algeria

WE2-H2.5: TECTONIC DEFORMATION ALONG THE DELHI-HARIDWAR RIDGE REVEALED 181 BY INSAR OBSERVATIONS: PRELIMINARY RESULTS

Himanshu Verma, Sumanta Pasari, Birla Institute of Technology and Science, India; Yogendra Sharma, Indian Institute of Technology Kanpur, India

WE2-H3: DATA ANALYSIS METHODS-1

WE2-H3.2: ARIMA MODEL TO PREDICT THE COVID-19 PANDEMIC CASES IN TELANGANA 185 STATE

Prisilla Jayanthi, St. Joseph’s Degree and PG College, India; Muralikrishna Iyyanki, Former Director (R & D) JNTU, India

WE2-H3.3: A NOVEL STATISTICAL PREPROCESSING APPROACH FOR HYPERSPECTRAL 190 IMAGE UNMIXING

Fatemeh Kowkabi, Marvdasht Branch, Islamic Azad University, Iran; Ahmad Keshavarz, Persian Gulf University, Iran; Lalit Kumar, EastCoast Geospatial Consultants, Australia

WE2-H3.4: HYPERSPECTRAL IMAGE CLUSTERING USING NEAREST NEIGHBOR..... 194

Anand Mehta, Institute of Infrastructure Technology Research and Management, India; Sumanta Pasari, Birla Institute of Technology and Science Pilani, India

WE2-H3.5: APPLICATION OF EMPIRICAL ORTHOGONAL FUNCTION ON GEODETIC 198 TIME-SERIES DATA

Neha Neha, Birla institute of Technology & Science, Pilani, India; Rohan Marwah, Sumanta Pasari, Birla Institute of Technology and Science, Pilani, Pilani Campus, India

WE2-H4: STUDENT SESSION-2

WE2-H4.1: A COMPARATIVE STUDY ON PROPAGATION MODELS FOR ROUTING 528 PROTOCOLS IN FANETS

Snehasish Basu, Sagnik Banerjee, Arindam Basak, Kalinga Institute of Industrial Technology, BHUBANESWAR, India; Tamesh Halder, Debashish Chakravarty, Indian Institute of Technology, Kharagpur, India; Amit Kumar Das, Institute of Engineering & Management, Kolkata, India; Sajal Sarkar, Power Grid Corporation of India Ltd., India; Arundhati Mishra Ray, Indian Space Research Organization, India

WE2-H4.2: FOREST STAND HEIGHT ESTIMATION BY INVERSION OF POLARIMETRIC 532 CANOPY SCATTERING MODELS

Faseela V S, Smitha Asok V, All Saints College, India; Sanid Chirakkal, Deepak Putrevu, Space Applications Centre, India

WE2-H4.3: SIMULTANEOUS EVALUATION OF THE TARGET SCATTERING-TYPE 537	
PARAMETER AND SCATTERING POWER COMPONENTS FROM POLARIMETRIC SAR IMAGES	
<i>Subhadip Dey, Narayanarao Bhogapurapu, Abhinav Verma, Avik Bhattacharya, Indian Institute of Technology Bombay, India; Saeid Homayouni, INRS, Canada; Carlos Lopez-Martinez, Universitat Politècnica de Catalunya, Spain</i>	
WE2-H4.4: RETRIEVAL OF GRAPE CROP PHENOLOGY METRICS FROM TIME SERIES OF 541	
OPTICAL AND SAR DATA	
<i>M Sangeetharani, Eswar Rajasekaran, Indian Institute of Technology Bombay, India; Parag Narvekar, Sensartics Private Limited, India; Sachin Walunj, Vilas Shinde, Sahyadri Farmer Producers Company Limited, India</i>	
WE2-H4.5: CROP GROWTH ASSESSMENT USING SENTINEL-1 GRD SAR DESCRIPTORS 545	
<i>Narayanarao Bhogapurapu, Subhadip Dey, Abhinav Verma, Avik Bhattacharya, MRS Lab, Indian Institute of Technology Bombay, India, India; Carlos Lopez-Martinez, Universitat Politècnica de Catalunya, Spain; Praveen Pankajakshan, CropIn Technology Solutions Pvt. Ltd., India</i>	
WE2-H4.6: MODERN MATHEMATICAL MODELLING APPROACHES FOR OPTIMIZED 549	
ESTIMATION OF SURFACE, DOUBLE BOUNCE AND VOLUMETRIC SCATTERING USING POLARIMETRIC ORIENTATION ANGLE AND INCLINATION ANGLE	
<i>Farhan Hai Khan, Nirmalya Misra, Institute of Engineering and Management, India; Tamesh Halder, Indian Institute of Technology Kharagpur, India; Rintu Kumar Gayen, Institute of Engineering and Management, India; Arundhati Misra Roy, Indian Space Research Organization, India; Debashish Chakravarty, Indian Institute of Technology, Kharagpur, India</i>	
WE2-H4.7: ANALYZING THE NUMBER OF LOOKS FROM STOCHASTIC DISTANCE IN 553	
POLARIMETRIC SAR IMAGERY	
<i>Nirmalya Misra, Rintu Kumar Gayen, Institute of Engineering and Management Kolkata, India; Tamesh Halder, Debashish Chakravarty, Indian Institute of Technology, Kharagpur, India; Arundhati Misra Roy, Indian Space Research Organization, India; Avik Bhattacharya, Indian Institute of Technology Bombay, India</i>	
WE2-H4.8: UNFOLDING THE CONTRIBUTION OF ENVIRONMENTAL AND 557	
ANTHROPOGENIC VARIABLES IN FOREST FIRE OVER WESTERN HIMALAYAN FIRE REGIME	
<i>Somnath Bar, Bikash Parida, Central University of Jharkhand, India; B. Uma Shankar, Indian Statistical Institute, Kolkata, India</i>	
 WE3-H1: AGRICULTURE, HYDROLOGY & CRYOSPHERE-4	
WE3-H1.1: RETRIEVAL OF MASS BALANCE OF AUSTRE GRØNFJORDBREEN IN THE 202	
WESTERN SVALBARD	
<i>Rajat Rajat, Virendra Rathore, Birla Institute of Technology Mesra, India; Bala Nela, Gulab Singh, Indian Institute of Technology Bombay, India; Andrey Glazovsky, Institute of Geography, Russian Academy of Sciences, Russia</i>	
WE3-H1.2: SNOW GRAIN SIZE AND ALBEDO RETRIEVALS FOR A SNOW AGING EVENT – A 206	
CASE STUDY COMPARING DIFFERENT RADIATIVE TRANSFER MODELS	
<i>Chander Shekhar, H S Negi, S K Dewali, Sanjeev Kumar, Defence Geo-informatics Research Establishment, India; Sunita Srivastava, 1. Panjab University 2. Central University of Haryana, India</i>	
WE3-H1.3: SNOW COVER CHARACTERIZATION USING L-BAND POLSAR DATA IN PARTS OF 210	
THE HIMALAYA	
<i>Sanjeev Kumar, Abhishek Narayan, Chander Shekhar, Snehamani Snehamani, DGRE Chandigarh, India; Gulab Singh, CSRE IIT Bombay, India; Devinder Mehta, Dept of Physics PU Chandigarh, India</i>	
WE3-H1.4: SENSITIVITY ANALYSIS OF CROP BIOPHYSICAL PARAMETERS USING 214	
MULTI-TEMPORAL DUAL-POLARIZATION SENTINEL -1 C-BAND SAR DATA	
<i>Rucha Dave, Amit Kushwaha, Anand Agricultural University, India; Koushik Saha, Indian Institute of Technology, India; Dharmendra Kumar Pandey, Deepak Putrevu, Arundhati Misra, Space Applications Centre, ISRO, India; Manisha Vitthalpura, Indus University, India</i>	

WE3-H1.5: RETRIEVAL OF SOIL MOISTURE USING HYBRID MODEL FOR SENTINEL 1 SAR DATASET 218

Shafiyoddin Sayyad, Ajit Kumar Yadav, Milliya College, Beed, India, India; Dharmendra Kumar Pandey, Anup Kumar Das, Space Application Center (ISRO), India

WE3-H2: GEOSCIENCE-2

WE3-H2.1: USE OF SHANNON INFORMATION ENTROPY IN EARTHQUAKE NOWCASTING 222

Sumanta Pasari, Priyesh Agarwal, Neha Neha, Birla Institute of Technology and Science Pilani, India

WE3-H2.3: SCATTERING MECHANISM BASED DECISION RULE CLASSIFIER FOR LAND COVER CLASSIFICATION USING MULTI POLARIZED SYNTHETIC APERTURE DATA(SAR) DATA 226

Shrut Kharod, Birla Institute of Technology and Science Pilani, India; Khyat Patel, Nirma University, India; Parul Patel, ISRO, India; Hari Shanker Srivastava, IIRS, India

WE3-H3: DATA ANALYSIS METHODS-2

WE3-H3.2: LONG TERM PREDICTION OF RAIN RATE AND ATTENUATION USING ANN AND RNN ALGORITHMS 230

Divya Rao, Indian Institute of Information Technology Kalyani, India; Dalia Nandi, Indian Institute of Information Technology, India; Fernando Pérez-Fontán, Vicente Pastoriza, Fernando Machado, Telecom Engineering School, Spain

WE3-H3.3: FUSION OF LOW-COST UAV POINT CLOUD WITH TLS POINT CLOUD FOR COMPLETE 3D VISUALISATION OF A BUILDING 234

Inshu Chauhan, Alok Rawat, MPS Chauhan, G.B. Pant Institute of Engineering and technology, Ghurdauri, India; RD Garg, IIT Roorkee, India

WE3-H3.4: MULTIMODAL AND MULTI-TEMPORAL SPATIAL DATA ANALYSIS IN GOOGLE EARTH ENGINE CLOUD COMPUTING PLATFORM TO DETECT HUMAN SETTLEMENTS WITHOUT ELECTRICITY: A CASE STUDY OF BANGALORE CITY 238

Manjunath Bhimappa Ujjinakoppa, Uttam Kumar, Rahisha Thottolil, Anindita Dasgupta, IIIT Bangalore, India

WE3-H3.5: GRADIENT BASED SPECTRAL SIMILARITY MEASURE FOR HYPERSPECTRAL IMAGE ANALYSIS 242

Parasuram Yadav Palla, Amba Shetty, Raghavendra BS, Narasimhadhan AV, National Institute of Technology Karnataka, Surathkal, India

WE3-H3.6: ASSESSMENT OF TOPOLOGICAL PATTERN OF ROAD NETWORK: A CASE STUDY OF BANGALORE CITY 246

Rahisha Thottolil, Uttam Kumar, IIIT Bangalore, India

WE3-H3.7: URBAN HEAT ISLAND AND ITS IMPACT ON IMPERVIOUS SURFACES DURING TWO SEASONS: A CASE STUDY OF BANGALORE 250

Anindita Dasgupta, Uttam Kumar, IIIT Bangalore, India

WE3-H4: LAND, FOREST & ENVIRONMENT-3

WE3-H4.1: A COMPARATIVE EVALUATION OF IMAGE CLASSIFICATION ALGORITHM IN A SEMI-ARID REGION USING SENTINEL 2B 254

Ravichandran Venkatesh, Periasamy Thilagaraj, Abdul Rahaman Sheik Mohideen, Masilamani Palanisamy, Bharathidasan University, India; Anup Kumar Das, Space Applications Centre, India

WE3-H4.2: INVESTIGATING THE EFFECT OF COVID INDUCED LOCKDOWN ON LAND SURFACE TEMPERATURE OVER AHMEDABAD CITY 258

Misal Shah, Rajesh Iyer, St Xavier's College, India; Akhil S. Nair, Deepak H. Gadani, School of Science, India; Tejas Turakhia, Tejas V. Shah, Deepali H. Shah, Gujarat Technological University, India; Mehul R. Pandya, ISRO, India

WE3-H4.4: DEVELOPMENT OF VIEW ANGLE DEPENDENT SPLIT-WINDOW ALGORITHM 261 FOR RETRIEVING LAND SURFACE TEMPERATURE FROM MODIS THERMAL INFRARED DATA <i>Jalpesh Dave, Himanshu Trivedi, N. V. Patel College of Pure and Applied Sciences, India; Mehul Pandya, SAC-ISRO, India; Vishal Pathak, St. Xavier's College, India; Dhiraj Shah, Sir P. T. Sarvajanic College of Science, India</i>	261
WE3-H4.5: COMPARATIVE ANALYSIS OF NAVIC MULTIPATH AMPLITUDE AND PHASE FOR 265 SOIL MOISTURE SENSITIVITY OVER DIFFERENT LAND COVER <i>Sushant Shekhar, Rishi Prakash, Graphic Era Deemed to be University, India; Dharmendra Kumar Pandey, Deepak Putrevu, Arundhati Misra, ISRO, India; Anurag Vidyarthi, Graphic Era Deemed University, India</i>	265
TH2-H1: NISAR-1	
TH2-H1.2: NISAR MISSION OVERVIEW AND UPDATES ON ISRO SCIENCE PLAN 269 <i>Anup Das, ISRO, Space Applications Centre, India; Raj Kumar, ISRO, National Remote Sensing Centre, India; Paul Rosen, NASA, Jet Propulsion Laboratory, United States</i>	269
TH2-H1.3: NISAR DATA CALIBRATION PLAN 273 <i>Shweta Sharma, Saurabh Tripathi, Santhisree B., Jayasri P.V., V Manavalan Ramanujam, Usha Sundari Ryali, Rakesh Bhan, Raj Kumar, ISRO, India</i>	273
TH2-H1.4: ECOSYSTEM APPLICATIONS OPPORTUNITIES WITH NISAR..... 277 <i>Anup Das, C Patnaik, Saroj Maity, Praveen Gupta, Dharmendra Kumar Pandey, Space Applications Centre, ISRO, India; G Rajashekar, KV Ramana, National Remote Sensing Centre, ISRO, India; KR Manjunath, Indian Space Research Organisation, India; Hitendra Padalia, Indian Institute of Remote Sensing, ISRO, India</i>	277
TH2-H1.5: ACTIVE-PASSIVE APPROACH FOR NISAR HIGH RESOLUTION SOIL MOISTURE 281 PRODUCTS: RETRIEVAL AND ACCURACY ASSESSMENT OVER INDIAN CROPLAND <i>Dharmendra Kumar Pandey, Anup Das, Deepak Putrevu, Arundhati Misra, Raj Kumar, Indian Space Research Organization, India; Srinivasa Teja Noothi, Shashi M., National Institute of Technology, Warangal, India; Prashant K. Srivastava, Banaras Hindu University, Varanasi, India; Om Pal, Kapil Rohilla, Ravindra Prawasi, Nijbul H. Sekh, Sushma Bisht, Haryana Space Applications Centre, Hisar, India</i>	281
TH2-H2: AI IN RS & GIS + BIG DATA-1	
TH2-H2.2: NEURAL NETWORK BASED RETRIEVAL OF INHERENT OPTICAL PROPERTIES 285 (IOPS) OF COASTAL WATERS OF OCEANS <i>Vyom Pathak, Brijesh Bhatt, Dharmsinh Desai University, India; Arvind Sahay, Mini Raman, Indian Space Research Organization, India</i>	285
TH2-H2.3: AUTOMATIC CLUSTERING OF HYPERSPECTRAL IMAGES USING QUTRIT 289 EXPONENTIAL DECOMPOSITION PARTICLE SWARM OPTIMIZATION <i>Siddhartha Bhattacharyya, Rajnagar Mahavidyalaya, Birbhum, India; Tulika Dutta, Somnath Mukhopadhyay, Assam University, India</i>	289
TH2-H2.4: UNSUPERVISED CHANGE DETECTION IN VERY HIGH RESOLUTION 293 MULTI-SPECTRAL IMAGES <i>Avinash Chouhan, North Eastern Space Applications Centre, India; Aryan Agrawal, Arijit Sur, Indian Institute of Technology Guwahati, India</i>	293
TH2-H2.5: TROPICAL CYCLONE INTENSITY PREDICTION USING BEST TRACK DATA 297 OVER NORTH INDIAN OCEAN BY MACHINE LEARNING CLASSIFIERS <i>Chinmoy Kar, Sikkim Manipal Institute of Technology, India; Sreeparna Banerjee, Maulana Abul Kalam Azad University of Technology, India</i>	297

TH2-H3: MISSION, SENSORS & CALIBRATION-1

TH2-H3.2: EFFECT OF LOOK DIRECTION AND FREQUENCY ON IDENTIFICATION OF LANDSLIDES USING AIRBORNE SAR DATA 301

Tapas Ranjan Martha, Priyom Roy, Kumranchat Vinod Kumar, NRSC, India

TH2-H3.3: RESOURCESAT2- AWIFS SENSOR ON-ORBIT RADIOMETRIC CONSISTENCY ASSESSMENT USING RADCALNET DATA 304

Saritha P K, Raghavender N, Santhisree B, Vinod M Bothale, National Remote Sensing Centre-ISRO, India

TH2-H3.4: DESIGN, PROCESS FLOW AND IMPLEMENTATION OF NOVASAR-1 SCENE-BASED DATA PRODUCT GENERATION AT IMGEOS 308

Haripriya S, Samvram Sahu, Raghvendra Joshi, Raji Jose, Ushasundari HSV, Santhisree B, Sauvic Dutta, Suryakalyani M, Sitakumari EVS, Manjusarma S, NRSC/ISRO, India

TH2-H3.5: EFFECTIVE UTILIZATION OF A LOW-COST SOLUTION FOR REMOTE SENSING OF VEHICLES AND PEDESTRIANS 312

Neerav Sharma, Rahul Dev Garg, Indian Institute of Technology, Roorkee, India

TH2-H4: ATMOSPHERE, CAPACITY BUILDING-1

TH2-H4.2: STUDY OF PARTICULATE MATTER OVER AHMEDABAD AND GANDHINAGAR CITIES: A CASE STUDY OVER TWO YEARS 316

Dhyani Vadgama, Tejas Turakhia, Akhil S. Nair, Rajesh Iyer, St. Xavier's College (Autonomous), Ahmedabad, India; Abha Chhabra, Space Applications Centre(SAC), ISRO, Ahmedabad, India

TH2-H4.3: STUDYING THE TREND OF CARBON MONOXIDE FOR LOCKDOWN PERIOD OVER INDIA 320

Khushali Tank, Rajesh Iyer, St. Xavier's college (Autonomous), India; Tejas Turakhia, Tejas V. Shah, Deepali H. Shah, Gujarat Technological University, India; Akhil S. Nair, Deepak H. Gadani, University School of Sciences, Gujarat University, Ahmedabad, India; Mehul R. Pandya, Space Application Center, ISRO, India

TH2-H4.4: RECONSTRUCTION OF SOLAR RADIO FLUX USING EARTH EQUATORIAL IONOSPHERE DATA 324

Megha Maheshwari, Nirmala Srini, U R Rao Satellite Centre, India

TH2-H4.5: SPATIO-TEMPORAL VARIATION OF PARTICULATE MATTER (PM10 AND PM2.5) OVER AHMEDABAD 328

Triya Belani, Rajesh Iyer, St. Xavier's College (Autonomous), India; Tejas Turakhia, Tejas V. Shah, Deepali H. Shah, Gujarat Technological University, India; Akhil S. Nair, Deepak H. Gadani, Gujarat University, India; Mehul R. Pandya, ISRO, India

TH3-H1: NISAR-2

TH3-H1.1: THE NISAR MISSION FOR ENHANCED DISASTER MONITORING 332

Manjusree Panchagnula, Tapas Martha, Raj Kumar, National Remote Sensing Centre, India; Arijit Roy, Indian Institute of Remote Sensing, India; Srinivasa Rao G, Shantanu Bhatwdeka, ISRO HQ, India

TH3-H1.2: POTENTIAL OF NISAR MISSION FOR IMPROVED FLOOD DISASTER STUDIES 336

Manjusree Panchagnula, National Remote Sensing Centre, India

TH3-H1.4: CHARACTERIZATION OF S-BAND SAR DATA AS A PRECURSOR TO NISAR 344

Niharika Karumuri, Jayasri Poludasu, Gowrisankar Sreeram, Ramu Yerukala, Ushasundari Ryali, Santhisree Basavaraju, Sitakumari Emani, Vinod Bothale, NATIONAL REMOTE SENSING CENTRE, INDIAN SPACE RESEARCH ORGANISATION, India

TH3-H1.5: OIL PLATFORM DETECTION FROM AIRBORNE L- AND S-BAND SAR DATA 348 USING THRESHOLDING AND YOLOV5	348
<i>Vaishali Chaudhary, Shashi Kumar, Indian Institute of Remote Sensing-ISRO, India</i>	
TH3-H1.6: IMPACT OF TRAINING DATA QUALITY ON MACHINE LEARNING BASED CROP 352 CLASSIFICATION USING TIME SERIES C-BAND SAR DATA	352
<i>Ayan Das, Mukesh Kumar, Saroj Maity, Bimal Bhattacharya, Space Applications Centre, Indian Space Research Organisation, India</i>	
TH3-H1.7: EVALUATING THE EFFECT OF POA COMPENSATION ON POLINSAR 356 COHERENCE FOR L-AND-S BAND AIRBORNE SAR DATA	356
<i>Shahid Shafai, Hossein Aghababaei, Anurag Kulshrestha, University of Twente, India; Shashi Kumar, Indian Institute of Remote Sensing, Netherlands</i>	
 TH3-H2: AI IN RS & GIS + BIG DATA-2	
TH3-H2.2: LANDSLIDE SUSCEPTIBILITY MODELLING USING DEEP LEARNING AND 360 MACHINE-LEARNING METHODS-A STUDY FROM SOUTHERN WESTERN GHATS, INDIA	360
<i>Achu A L, Kerala University of Fisheries and Ocean Studies (KUFOS), India; Girish Gopinath, Kerala University of Fisheries and Ocean Studies (KUFOS), India; Surendran U, Centre for Water Resources Development and Management, India</i>	
TH3-H2.3: SEMANTIC SEGMENTATION OF L&S BAND SAR DATA AFTER TUNING THE 365 HYPER PARAMETERS IN MACHINE LAEARNING MODELS	365
<i>Anil Kumar, Susheela Dahiya, University of Petroleum and Energy Studies, India; Rajat Garg, Lloyd Institute of Engineering and Technology/University of Petroleum and Energy Studies, India; Manish Prateek, Dev Bhoomi Group of Institutions, India; Shashi Kumar, Indian Institute of Remote Sensing, ISRO, India</i>	
 TH3-H3: MISSION, SENSORS & CALIBRATION-2	
TH3-H3.2: SINGLE BAND DUAL POLARIZATION GROUND BASED GNSS 369 REFLECTOMETRY: SYSTEM DESIGN AND FIELD EXPERIMENTS	369
<i>Ananya Ray, Anish Mishra, Shweta Sharma, Vivan Prakash, Vinit Kumar, Akshay Pande, Renuka Tandan, Saumi De, Devendra Sharma, Deepa Sharma, Dharmendra Kr. Pandey, Deepak Putrevu, Vivek Brahmabhatt, Jogeswara Rao, Rakesh Kr. Bhan, Rajeev Jyoti, Space Application Centre, ISRO, India</i>	
TH3-H3.3: WHAT DOES THE NEW RISAT-1A 8-BEAM MRS MODE HOLD FOR THE 373 APPLICATIONS COMMUNITY?	373
<i>C Patnaik, Jayaprasad P, Deepak Putrevu, Space Applications Centre, India</i>	
 TH3-H4: ATMOSPHERE, CAPACITY BUILDING-2	
TH3-H4.1: REVEALING THE DECLINING TREND OF NO2 AND SO2 CONCENTRATION IN 377 INDIAN CITIES DURING PANDEMIC LOCKDOWN	377
<i>Ravichandran Venkatesh, Bharathidasan University, India; Anup Kumar Das, Space Applications Centre, India; Janakiraman A, CGI Information Systems & Management Consultants, India</i>	
TH3-H4.2: ASSESSMENT OF BLACK CARBON CONCENTRATION AND DELTA C OVER 381 AHMEDABAD.	381
<i>Savan Panchal, St. Xavier's college Ahmedabad. Gujarat, India; Tejas Turakhia, Deepali H. Shah, Gujarat Technological University, Ahmedabad, Gujarat, India, India; Akhil S. Nair, Deepak H. Gadani, University School of Sciences, Gujarat University, Ahmedabad, Gujarat, India, India; Mehul R. Pandya, ISRO, Ahmedabad, India; Rajesh Iyer, St. Xavier's college(Autonomous), Ahmedabad, India; Tejas V. Shah, Gujarat Technological University, Ahmedabad, India</i>	

TH3-H4.3: SPATIOTEMPORAL VARIATION OF NITROGEN DIOXIDE (NO₂) OVER THE REGION OF AHMEDABAD CITY	385
<i>Vaibhav Trivedi, Rajesh Iyer, St. Xavier's College, Ahmedabad, India; Tejas Turakhia, Tejas V. Shah, Deepali H. Shah, Gujarat Technological University, Ahmedabad, India; Akhil S. Nair, Deepak H. Gadani, Gujarat University, Ahmedabad, India; Mehul R. Pandya, Space Applications Center, ISRO, Ahmedabad, India</i>	
TH3-H4.4: UNDERSTANDING THE VARIATION OF CARBON MONOXIDE OVER AHMEDABAD CITY	389
<i>Yogeshkumar A. Patel, St. Xavier's College (Autonomous), Ahmedabad 380009, India; Tejas Turakhia, Tejas V. Shah, Deepali H. Shah, Gujarat Technological University, India; Akhil S. Nair, Deepak H. Gadani, Gujarat University, India; Rajesh Iyer, St. Xavier's College (Autonomous), Ahmedabad-380009, India, India; Mehul R. Pandya, Space Applications Center, ISRO, Ahmedabad- 380015, India</i>	
TH3-H4.6: ESTIMATION OF AEROSOL RADIATIVE FORCING AT DIFFERENT SITE LOCATIONS IN AHMEDABAD CITY	397
<i>Shubham Jayswal, Heet S. Joshi, Tejas Turakhia, Akhil S. Nair, Rajesh Iyer, St. Xavier's College (Autonomous), Ahmedabad, India; Mehul R. Pandya, SAC - ISRO, India</i>	
FR1-H1: YOUNG PROFESSIONALS	
FR2-H1: ATMOSPHERE, CAPACITY BUILDING-3	
FR2-H1.1: A NUMERICAL EXPERIMENT TO STUDY THE EFFECT OF ANTHROPOGENIC HEAT AND MOISTURE ON LOCAL WEATHER	401
<i>Partha Sarathi Mishra, Srinivasa Ramanujam Kannan, IIT BHUBANESWAR, India</i>	
FR2-H1.2: VARIATIONS OF AEROSOL RADIATIVE FORCING DURING COVID-19 IMPOSED LOCKDOWN OVER AHMEDABAD CITY	405
<i>Heet S. Joshi, Shubham Jayswal, Tejas Turakhia, Akhil S. Nair, Rajesh Iyer, St. Xavier's College (Autonomous), Ahmedabad, India; Mehul R. Pandya, SAC-ISRO, India</i>	
FR2-H1.3: TOPOGRAPHIC AND METEOROLOGICAL CHALLENGES IN DISSEMINATION OF SOLAR TECHNOLOGIES: AN OVERVIEW OF LEH, INDIA	409
<i>Radhika Bhanja, Koel Roychowdhury, Presidency University, Kolkata, India</i>	
FR2-H2: UAV BASED RS	
FR2-H2.2: OPTIMAL PARAMETER SELECTION FOR UAV BASED PUSHBROOM HYPERSPECTRAL IMAGING	413
<i>Adduru U G Sankararao, Sanju Kumar N.T, Naresh Dharavath, P. Rajalakshmi, Indian Institute of Technology Hyderabad, India</i>	
FR2-H2.3: UAV-BASED TARGET LOCALIZATION IN DENSE AREAS WITH COMPUTER VISION AND GPS HYBRID NAVIGATION MODEL	417
<i>Jatin Upadhyay, Abhishek Rawat, Dipankar Deb, Institute of Infrastructure, Technology, Research And Management, India</i>	
FR2-H2.4: ADVANCED IMAGE PROCESSING APPROACH FOR COLOR-TEXTURE ANALYSIS OF UAV IMAGERY FOR WEED DETECTION IN SUGARCANE CROP.	421
<i>Vyomika Singh, Dharmendra Singh, Indian Institute of Technology, Roorkee, India</i>	
FR2-H2.5: EFFICIENT APPLICATION OF AI FOR TARGET TRACKING AND MONITORING IN AIRBORNE IMAGES	425
<i>Vatsala Singh, Mody University of Science and Technology, India; Keshav P. Singh, IIT BHU, India</i>	

FR2-H2.6: CALIBRATION OF L& S BAND ASAR DATA USING ROSAMOND CORNER REFLECTOR ARRAY SITE	428
<i>Santhi Sree Basavaraju, Gowrisankar Sreeram, Niharika Karumuri, Jayasri PV, Vinod M Bothale, NATIONAL REMOTE SENSING CENTER, ISRO, India</i>	
FR2-H3: THERMAL REMOTE SENSING	
FR2-H3.2: LAND SURFACE TEMPERATURE ANOMALIES AS INDICATOR OF LAND COVER CHANGE: CASE STUDY OVER CHENNAI CITY	432
<i>Anusha Roy, Rahul Harod, Eswar Rajasekaran, Indian Institute of Technology Bombay, India</i>	
FR2-H3.3: EVAPOTRATIVE FLUX ESTIMATION OVER INDIAN REGION USING S-NPP OPTICAL AND THERMAL DATA	436
<i>Chandrasekar K, Nidhi Misra, Anurag Mishra, Madhavi P, Abdul Hakeem K, Venkateswar Rao V, NRSC , ISRO, India; Mohammed Ahamed J, NRSC, ISRO, India</i>	
FR2-H3.4: THERMAL AND SHORTWAVE INFRARED REMOTE SENSING OF ECOSYSTEM PROCESSES: OPPORTUNITIES, SYNERGIES, AND CHALLENGES	440
<i>Kaniska Mallick, Tian Hu, Ivonne Trebs, Martin Schlerf, Luxembourg Institute of Science and Technology, Luxembourg; Yun Bai, Qingdao University, China; Nishan Bhattarai, U.S. Department of Agriculture, France; Gilles Boulet, Centre d'Etudes Spatiales de la Biosphère, France; Tianxin Wang, Camilo Rey Sanchez, Robert Shortt, Dennis Baldocchi, University of California, Berkeley, United States</i>	
FR2-H3.5: EFFECT OF DIURNAL AND ANGULAR THERMAL INFRARED MEASUREMENTS ON FIELD-SCALE EVAPOTRANSPIRATION	444
<i>Rahul Nigam, Bimal K Bhattacharya, Space Applications Centre ISRO, India; Jaychandra Ravi, Parul Patel, Nirma University, India; Devansh Desai, Silver Oak Institute of Science, Silver Oak University, India</i>	
FR2-H3.6: INVESTIGATING THE TEMPORAL VARIABILITY OF SEA SURFACE TEMPERATURE OVER THE ENCLOSED WATER BODIES OF CORAL REEF LAGOON AT LAKSHADWEEP ISLANDS, INDIA	448
<i>Preeti Rajput, Ratheesh Ramakrishnan, Space Applications Centre (ISRO), India</i>	
FR2-H4: LUNAR SCIENCE	
FR2-H4.2: SPECTRAL CHARACTERIZATION OF VAPORUM DARK MANTLING DEPOSITS AND SURROUNDING REGION USING CHANDRAYAAN-1 MOON MINEROLOGY MAPPER	453
<i>Kumaresan P. R., Saravanavel J, Bharathidasan University, India</i>	
FR2-H4.3: INITIAL RESULTS FROM IMAGING INFRARED SPECTROMETER (IIRS) ONBOARD ISRO'S CHANDRAYAAN-2 FOR LUNAR MINERAL DETECTION	457
<i>Mamta Chauhan, Prakash Chauhan, Indian Institute of Remote Sensing (IIRS), India</i>	
FR2-H4.4: SCATTERING-BASED ANALYSIS OF SOUTH POLAR CRATER OF THE LUNAR SURFACE USING L-BAND SAR DATA OF CHANDRAYAAN-2 MISSION	459
<i>Shashi Kumar, Vaishali Chaudhary, Prakash Chauhan, Indian Institute of Remote Sensing (IIRS), ISRO, India; Awinash Singh, Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, Enschede 7514 AE, The Netherlands, Netherlands</i>	
FR2-H4.5: SCATTERING MECHANISMS ASSOCIATED WITH HIGH CIRCULAR POLARIZATION RATIOS FROM YOUNG, LARGE CRATERS ON THE MOON	463
<i>Sriram Bhiravarasu, Anup Das, Deepak Putrevu, Dharmendra Pandey, Tathagata Chakraborty, Indian Space Research Organization, India</i>	

FOREST STAND HEIGHT ESTIMATION BY INVERSION OF POLARIMETRIC CANOPY SCATTERING MODELS

Faseela V. Sainuddin¹, Sanid Chirakkal², Smitha V. Asok¹, Deepak Putrevu²

1. Department of Environmental Sciences, All Saints' College
Thiruvananthapuram 695007

2. Advanced Microwave and Hyperspectral, Techniques Development Group,
Space Application Centre, ISRO, Ahmedabad 380015

ABSTRACT

Physical scattering models can be employed for estimating propagation and attenuation of electromagnetic waves through forest canopies. With polarimetric SAR (PolSAR) data (including dual-pol data, by simplifying assumptions), we have enough information to suitably invert these models to estimate important biophysical forest parameters, such as the vegetation stand height. This paper successfully attempts the estimation of forest stand height using two microwave canopy scattering models, viz., single-scattering radiative transfer model and the dielectric cylinder model (with a common rough surface scattering model). The ground measurements were taken from the study area in the Western Ghats region of Kerala. Iterative Optimization method was used to invert the non-linear models and the height of trees were retrieved using dual-pol data from ALOS-2 satellite, over the test sites. The accuracy of model derived heights was estimated by comparing them to the heights of trees measured in-situ. The results indicated that the inversion of the dielectric cylinder model perform better, yielding a coefficient of determination (R^2) of 0.61 and a root mean square error (RMSE) of 3.16 m. The single scattering model produced relatively lower R^2 value of 0.47.

Index Terms— Canopy Scattering Models, Vector Radiative Transfer Modeling, Dielectric Cylinder, Biophysical Parameter

1. INTRODUCTION

Knowledge on biophysical properties of tropical forests retrieved from remote sensing data enables to improve monitoring of these unique areas, very often impenetrable. In particular, the use of Synthetic Aperture Radar (SAR) for monitoring forests has drawn a great attention in the past decades due to its ability to observe earth surface at all weather conditions and sensitivity to the dielectric and geometrical properties of size, shape and orientation of scattering elements. Because of the randomly oriented complex geometries of the various scattering particles, the radar scattering from natural

earth surfaces involves complicated electromagnetic wave interactions. Therefore, it is impossible to deal with all kinds of possible earth elements configurations and conditions in a single polarimetric radar scattering model for a vegetation layer over earth surfaces. Hence researchers attention was always focused on the development of approximate scattering models [1][2]. Many microwave scattering models have been developed to better understand the interaction of microwave signals with forests and other vegetated targets, and thereby to assist in forest parameter retrieval from synthetic aperture radar (SAR) measurements [1][3][4][5][6][7].

It is well known that the backscattering coefficient is not only affected by the radar system parameters such as frequency, polarization, and incident angles, but also the surface parameters such as soil roughness and moisture, and presence and structure of vegetation. Hence, accurate modeling of the propagation of microwaves through tree foliage is generally difficult due to the complexity of the tree electromagnetic geometry and its constituent elements, e.g. trunk, branches, and leaves, where dimensions are comparable to the microwave signal wavelength over a wide range of frequencies. Despite its complex nature, the canopy volume has been treated in the literature as a homogeneous mixture of discrete, randomly distributed and oriented dielectric disks and cylinders representing leaves and branches or trunks respectively [1][8].

Tree height is one of the important parameters for estimating Above Ground Biomass (AGB). Chave et al. reported that the addition of tree height can improve the efficiency of allometric models [9]. Lima et al. compared six allometric models and concluded that an allometric model including tree height had the highest R^2 [10]. The purpose of this paper is to show how the dual-pol ALOS-2 L-band data can be exploited to yield more accurate tree heights of the selected vegetation stands with the use of two canopy scattering models viz., the single-scattering radiative transfer model with Rayleigh particles and the defoliated trunk layer approximated as dielectric cylinder layer of finite length. Both these layers are sitting on a rough surface layer modeled using the state-of-the-art I^2EM model.

2. METHODOLOGY FOR HEIGHT ESTIMATION USING CANOPY SCATTERING MODELS

Of the available scatter models, we focused on single-scattering radiative transfer model with Rayleigh particles [11], and the model developed with reference to the model proposed by Karam and Fung [12]. These models, respectively referred to as Model I and Model II in this study, are both based on the vector radiative transfer theory (VRT) and were developed for microwave backscattering studies. A brief discussion is given in the following section regarding the geometrical description of the medium, the electromagnetic modelling of the signal-canopy interactions, the input parameters, and the output data. All the modeling and simulations were carried out using custom code in Python3 language whereas ALOS-2 data processing was carried out using ArcGIS software.

2.1. Model I: $I^2EM + S^2RT$

In this model, the vegetation is divided into two layers: the canopy layer, mainly includes the stems and leaves, and the ground layer includes the rough ground. Backscattering from the rough ground is modeled with Improved Integral Equation Method (I^2EM model). To compute the scattering at the diffuse air-canopy boundary, the model represent the canopy in terms of an equivalent, homogeneous dielectric medium. The total single-scattering backscattering coefficient is the sum of the four backscattering contributions. These contributions include: (a) single backscattering by the ground surface, (b) single direct backscattering by the canopy elements, (c) a combination of single bistatic scattering by the ground followed by single bistatic scattering by vegetation elements or the reverse sequence and (d) transmission through the canopy, to specular reflection by the ground surface, followed by backscatter by the vegetation volume, followed by another specular reflection by the ground surface.

$$\begin{aligned}\sigma_{pq}^0 &= \sigma_{g_{pq}}^0 + \sigma_{c_{pq}}^0 + \sigma_{cgtpq}^0 + \sigma_{gcpq}^0 \\ &= \gamma_p \gamma_q \sigma_{s_{pq}}^0 \theta_i + 4\pi \cos \theta_i \frac{1 - \gamma_p \gamma_q}{K_e^p + K_e^q} \frac{3K_s}{8\pi} \\ &\quad + 4\pi \cos \theta_i \gamma_p \gamma_q \Gamma^p \Gamma^q \frac{1 - \gamma_p \gamma_q}{K_e^p + K_e^q} \frac{3K_s}{8\pi} \\ &\quad + 4\pi \cos \theta_i \frac{H \gamma_p \gamma_q}{\cos \theta_i} \left(\frac{2\Gamma^p \Gamma^q}{\cos \theta_i} \right)\end{aligned}\quad (1)$$

Equation (1) referred is the S^2RT model with rayleigh scatterers under incoherent addition assumption, where $a = \frac{K_s}{K_e}$ is the single scattering albedo, H is the height of the medium.

2.2. Model II: $I^2EM +$ Dielectric cylinder layer

In model II, the medium is subdivided into a layer of defoliated vegetation as a collection of randomly oriented dielectric

cylinders of finite length and the underlying rough ground. The scattering amplitude and the extinction cross-section of an arbitrarily oriented single cylinder are calculated. The total backscattering coefficient is the sum of the two backscattering contributions including scattering from the randomly oriented cylinder layer and from the underlying surface. The first order solution of the radiative transfer equation is used to obtain the backscattering coefficient, which can be written as:

$$\sigma_{pq}^0(i) = \sigma_{c_{pq}}^0 + \sigma_{g_{pq}}^0 \quad (2)$$

where $\sigma_{c_{pq}}^0, \sigma_{g_{pq}}^0$ represents backscattering from the canopy and ground respectively. The backscattering coefficient due to the cylinder layer, $\sigma_{c_{pq}}^0$, can be written as [12]:

$$\begin{aligned}\sigma_{c_{pq}}^0 &= [4\pi \cos \theta_i / \langle K_e^p(i) \rangle + \langle K_e^q(i) \rangle] \\ &\quad \cdot \{1 - \exp[-(\langle K_e^p(i) \rangle + \langle K_e^q(i) \rangle) n_0 d \sec \theta_i]\} \\ &\quad \cdot \langle |f_{pq}(-i, i)|^2 \rangle\end{aligned}\quad (3)$$

where n_0 is the number of cylinders per unit volume and $f_{pq}(-i, i)$ and $K_e^{p/q}(i)$ are the scattering amplitude and extinction coefficient respectively. Similar to model I, the backscattering from the rough ground is modeled with I^2EM model. The α, β and γ angles are the Tait-Bryan angles. As cylinder orientation angles are non-correlated, the joint probability distribution function can be factored out as,

$$p(\alpha, \beta, \gamma) = p(\alpha)p(\beta)p(\gamma) \quad (4)$$

Due to symmetry of cylinders Euler angles can be used to describe cylinders by letting

$$\gamma = 0 \quad \text{and} \quad p(\gamma) = 1 \quad (5)$$

2.3. Ground data and input parameters of the models

The field surveys were conducted in the selected test sites in December, 2019 and March, 2021. The study area is located at the western slopes of southern Western Ghats in Thiruvananthapuram district of Kerala having different vegetation types. The measurements were taken by establishing plots of size 31.6×31.6 m. Sampling plots were established in all the major vegetation types of the area viz. moist deciduous, semi-evergreen and evergreen forests and forest plantations namely acacia and eucalyptus. Measured biophysical parameters include, tree height, trunk diameter, soil moisture and species names. ALOS-2 L-band dual-pol SAR data acquired of March, 2019 has been used in the study. Input Parameters to the models include frequency, incident angle and polarization, soil moisture, correlation length, surface roughness, dielectric constant, tree height and trunk radius. Forest biophysical parameters were assumed to have remained unchanged during the survey period. Therefore, tree density, diameter

at breast height, canopy height, soil moisture and vegetation water content were assumed constant. The input height of the vegetation stand in each plot was the median value of the heights in the respective plot.

2.4. Inverse problem for height Estimation

The estimation of trunk heights using a canopy scattering model can be stated as an inverse problem. In this study, Iterative optimization (IO) approach was used to retrieve heights. The iterative optimization is a popular technique for the inversion of ill-posed problems [13]. Let \mathbf{Y} be the vector of output variables related to the vector of input variables \mathbf{X} by the model \mathbf{M} as $\mathbf{Y} = \mathbf{M}(\Theta, \mathbf{X}) + \epsilon$, where Θ is the vector of model parameters. The inversion process determines \mathbf{X} by minimizing a merit function $S(\mathbf{X})$ for n number of observations by,

$$S(\mathbf{X}) = \sum_{i=1}^n [Y_i - M(\Theta, X_i)]^2 \quad (6)$$

In general, this merit function is non-linear and is solved by classical optimization techniques, e.g., Nelder-Mead Simplex method [14]. The method starts with an initial guess of the variables and is iteratively updated while the merit function approaches towards a minimum. The minimization problem is re-written as a constrained non-linear multivariate scalar function. The range of acceptable height was constrained by 3 - 25m. In between these ranges, the values of X_i that minimize the merit function (using a non-linear L-BFGS-B algorithm [15]) are selected as the optimal result. For validation purpose, the modelled tree heights were compared with ground measurements at the study sites. One point from each vegetation type was used for fine tuning the forward model and the remainder of data used as independent validation points. The performance of the inversion was assessed in terms of the coefficient of determination (R^2) and root mean square error (RMSE) between estimated and observed tree heights. A vegetation stand height map was prepared from model II. To reduce the computing time in the optimization process, the ALOS -2 image was resampled to 100m pixel size and the non- vegetation areas are masked out in the process

3. RESULTS AND DISCUSSION

This section discusses the results of forest height retrieved using the models I & II with ALOS-2 data along with the validation of each using field measurements. Linear relationships between vegetation stand heights and polarizations of ALOS-2 data showed a relatively high R^2 value for HV polarization ($R^2 = 0.26$) in comparison to HH polarization ($R^2 = 0.034$). The validation of height estimated from model I with ground measured values resulted in a R^2 value of 0.47 with an RMSE of 4.01 m. See Fig. 1 for the regression plot.

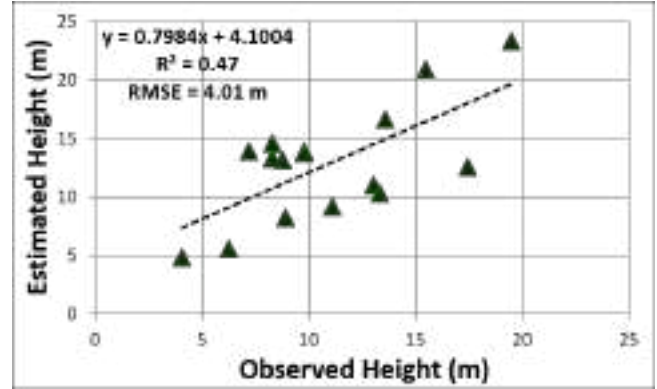


Fig. 1. Validation plot of tree height from model I with ground measured data

Whereas the retrieval accuracy has improved further using model II (See Fig. 2). Here, the R^2 value between the observed and the estimated height is 0.61 with a better RMSE value of 3.16 m. This shows that the predicted values from model II are more correlated to the field values. This makes the case for adding a trunk component to the model, instead of a homogeneous layer of spherical particles, to achieve a better accuracy in estimation of forest stand height. Fig. 3 shows the estimated tree height map obtained by model II inversion in the study area..

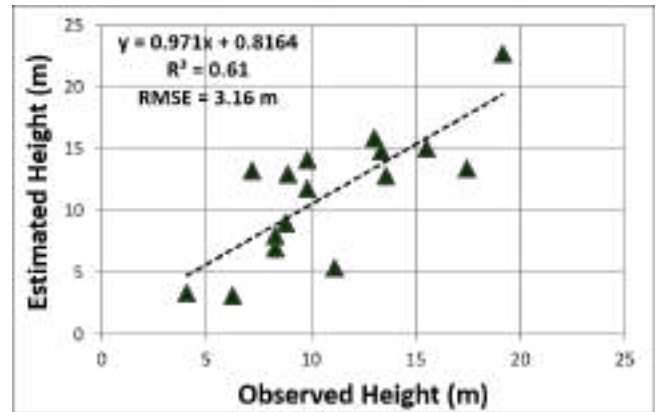


Fig. 2. Validation plot of tree height from model II with ground measured data

4. CONCLUSIONS

In this work, two polarimetric microwave canopy scattering models were compared for their accuracy in tree height estimation, which is a problem of paramount importance in forestry. The retrieved heights from the two methods were compared to the measured heights from the field. ALOS-2 L-band data at HH and HV polarizations were used in the study.

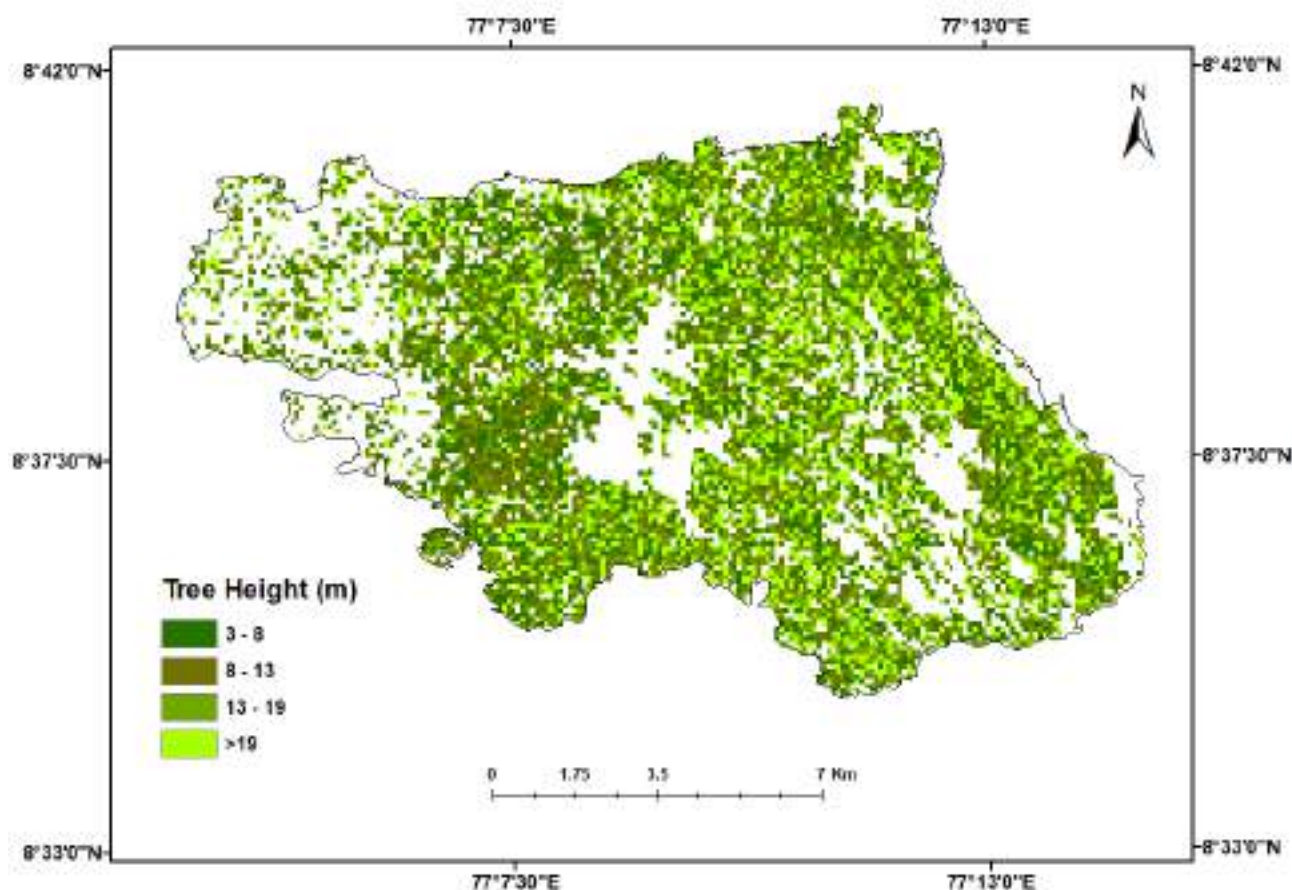


Fig. 3. Vegetation stand height map of the study area (100m pixel size).

The canopy models chosen were S^2RT model (model I) and dielectric cylinder model (model II), with a common I^2EM surface scattering layer. The Ground measurement data was collected from the tropical forests of Kerala in December, 2019 and March, 2021. Inversion methodology adopted was the Iterative Optimization (IO) method. Out of the two models, the highest correlation ($R^2 = 0.61$) and lowest error of estimation (RMSE = 3.16 m) were reported for model II. Results presented here demonstrate that adding the trunk layer into the canopy model improves the accuracy of forest biophysical parameter retrieval. Further, the study shows that the dual polarized SAR modes and in-situ measurements collected systematically can be adeptly employed to retrieve tree biophysical parameters from tropical forests. Adding the height component to the allometric model can improve the model efficiency in estimating AGB. Hence the predicted height values along with Diameter at Breast Height (DBH) in the allometric models can be used for estimating AGB of the study area. This constitutes part of an ongoing work from authors. Since the study involves complex physical modelling, a number of input parameters had to be fixed for running

the model. Further, increasing the number and spread of the ground truth points in the rather inaccessible terrains of tropical Western Ghats was also a constraint. Addressing these issues and exploring options for multi frequency SAR data analysis encompassing future NISAR mission offers ample scope for updation of the study methodology.

5. ACKNOWLEDGEMENT

Authors thankfully acknowledge the funding support provided by Space Application Centre, ISRO, as part of L&S airborne PI Scheme.

6. REFERENCES

- [1] F.T.Ulaby, K.Sarabandi, K.McDonald, M.Whitt, and M.Dobson, "Michigan microwave canopy scattering model," *International Journal of Remote Sensing*, vol. 11, p. 1223–1253, 1990.
- [2] L.Tsang, J.A.Kong, and R.T.Shin, "Theory of

- microwave remote sensing (new york: Wiley-interscience),” in *Theory of microwave remote sensing (New York: Wiley-Interscience)*, vol. II. Wiley-Blackwell, 1985.
- [3] R.H.Lang and J.S.Sidhu, “Electromagnetic backscattering from a layer of vegetation: A discrete approach,” *IEEE Transactions on Geoscience and Remote Sensing*, vol. 21, p. 177–186, January 1993.
- [4] S.L.Durden, J.J.VanZyl, and H.A.Zebker, “Modeling and observation of the radar polarization signature of forested areas,” *IEEE Transactions on Geoscience and Remote Sensing*, vol. 27, p. 290–301, May 1989.
- [5] J.A.Richards, G.Q.Sun, and D.S.Simonett, “L-band radar backscattering modeling of forest stands,” *IEEE Transactions on Geoscience and Remote Sensing*, vol. 25, p. 487–498, July 1987.
- [6] Y.C.Lin and K.Sarabandi, “Electromagnetic scattering model for a tree trunk above a tilted ground plane,” *IEEE Transactions on Geoscience and Remote Sensing*, vol. 33, p. 1063–1070, July 1995.
- [7] G.Picard, T.L.Toan, S.Quegan, Y.Caraglio, and T.Castel, “Radiative transfer modeling of cross-polarized backscatter from a pine forest using the discrete ordinate and eigenvalue method,” *IEEE Transactions on Geoscience and Remote Sensing*, vol. 42, p. 1720–1730, August 2004.
- [8] S.A.Torricco, H.L.Bertoni, and R.H.Lung, “Modelling tree effects on path loss in a residential environment,” *IEEE Transactions on Antennas and Propagation*, vol. 46, p. 872–880, June 1998.
- [9] J. Chave, C. Andalo, S. Brown, M. A. Cairns, J. Q. Chambers, D. Eamus, H. Folster, F. Fromard, N. Higuchi, T. Kira, J. Lescure, , B. W. Nelson, H. Ogawa, H. Puig, B. Rie ´ra, and T. Yamakura, “Tree allometry and improved estimation of carbon stocks and balance in tropical forests,” *Oecologia*, vol. 145, pp. 87–99, October 2005.
- [10] A. J. N. Lima, R. Suwa, G. H. P. de Mello Ribeiro, T.Kajimoto, J. dos Santos, R. P. da Silva, C. A. S. de Souzaa, P. C. de Barrosa, H. Noguchib, M. Ishizukab, and N. Higuchi, “Allometric models for estimating above- and below-ground biomass in amazonian forests at são gabriel da cachoeira in the upper rio negro, brazil,” *Forest Ecology and Management*, vol. 277, pp. 163–172, April 2012.
- [11] F.T.Ulaby, D.G.Long, W.J.Blackwell, C.Elachi, A.K.Fung, C.Ruf, and J.VanZyl, “Microwave radar and radiometric remote sensing,” in *Microwave radar and radiometric remote sensing*, vol. I. The University of Michigan Press, 2014, pp. 461–467.
- [12] M.A.Karam and A.K.Fung, “Electromagnetic scattering from a layer of finite length, randomly oriented, dielectric, circular cylinders over a rough interface with application to vegetation,” *International Journal of Remote Sensing*, vol. 9, pp. 1109–1134, October 1988.
- [13] Y.Wang, “Quantitative remote sensing inversion in earth science: Theory and numerical treatment,” in *Quantitative Remote Sensing Inversion in Earth Science: Theory and Numerical Treatment*, vol. II. Springer-Verlag Berlin Heidelberg, 2010, p. 785–812.
- [14] S.Jacquemoud, F.Baret, B.Andrieu, F.Danson, and K.Jaggard, “Extraction of vegetation biophysical parameters by inversion of the prospect+ sail models on sugar beet canopy reflectance data, application to tm and aviris sensors,” *Remote Sensing of Environment*, vol. 46, p. 163–172, June 1998.
- [15] J.L.Morales, “A numerical study of limited memory bfgs methods,” *Applied Mathematics Letters*, vol. 15, pp. 481–487, January 2001.

Copyright ©2021 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved.

Copyright and Reprint Permission: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923. For reprint or republication permission, email to IEEE Copyrights Manager at pubs-permissions@ieee.org. All rights reserved. Copyright ©2021 by IEEE.

The papers in this book comprise the proceedings of the meeting mentioned on the cover and title page. They reflect the authors' opinions and, in the interests of timely dissemination, are published as presented and without change. Their inclusion in this publication does not necessarily constitute endorsement by the editors, the IEEE Geoscience and Remote Sensing Society, or the Institute of Electrical and Electronics Engineers, Inc.

IEEE Catalog Number: CFP21U63-ART
ISBN: 978-1-6654-4249-7

Assembled by Conference Management Services, Inc.



